REMARKS

This Amendment is fully responsive to the final Office Action dated December 23, 2009, issued in connection with the above-identified application. A request for continued examination (RCE) and a three-month extension of time are included. Claims 2-6 are pending in the present application. With this Amendment, claims 2-6 have been amended; and claims 7 and 8 have been added. No new matter has been introduced by the amendments made to the claims or by the new claims added. Favorable reconsideration is respectfully requested.

In the Office Action, claims 2, 5 and 6 been rejected under 35 U.S.C. 103(a) as being unpatentable over Tsukamoto (U.S. Publication No. 2004/0026381, hereafter "Tsukamoto") in view of Terada (U.S. Patent No. 5,155,329, hereafter "Terada") or Chou et al. (U.S. Patent No. 5,961,859, hereafter "Chou") and Kearney (U.S. Patent No. 4,446,354, hereafter "Kearney").

The Applicants traverse this rejection for the reasons noted below.

With regard to independent claim 2, the Applicants assert that the above cited prior art fails to disclose or suggest all the features recited in independent claim 2.

Independent claim 2 recites *inter alia* the following features:

"[a] laser welding method, comprising:...

<u>detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion</u>;

<u>analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output</u>; and

<u>setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum</u>." (Emphasis added).

The present invention (as recited in independent claim 2) is distinguishable from the cited prior art in that the laser welding method detects a time change in light emission strength of a plasma or a plume generated from a laser welded portion, and analyzes frequency characteristics of the light emission to obtain an amplitude of a frequency component which is the same variation frequency of the laser output. Additionally, a laser output variation condition is set so that the amplitude of the frequency component becomes a maximum.

Preventing weld defects greatly depends on "a waveform of the variation" and "a frequency of the variation" in the laser output, so it is important to optimize conditions of the variations in the laser output. The present invention (as recited in independent claim 2) has

determined that the peak of the amplitude in the frequency component of the light emission of a plasma or a plume which matches with the variation frequency of the laser output is the largest at optimum welding conditions (see Applicants' disclosure pg. 9, lines 3-8 and Fig. 4).

Thus, the present invention (as recited in independent claim 2) detects a time change in light emission strength of a plasma or a plume generated from a laser welded portion, analyzes frequency characteristics of the light emission to obtain an amplitude of a frequency component which is the same variation frequency of the laser output, and sets a laser output variation condition so that the amplitude of the frequency component becomes a maximum.

In the Office Action, the Examiner relies on the combination of Tsukamoto, Terada or Chou, and Kearney for disclosing or suggesting all the features recited in independent claim 2. However, the Applicants assert that the combination of Tsukamoto, Terada or Chou, and Kearney fails to disclose all the features of the "detecting," "analyzing" and "setting" steps recited in independent claim 2.

Tsukamoto discloses a laser welding method for preventing welding defects by modulating a laser output in accordance with the frequency of a molten-pool (i.e., the periodic movement of the molten metal). That is, a pulse laser output is controlled to conform to the frequency of the reciprocating motion of molten metal (see e.g., ¶[0026]-¶[0027]).

In the Office Action, the Examiner acknowledges that Tsukamoto fails to disclose or suggest "detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion" (i.e., "detecting" step), as recited in independent 2. (see Office Action, pg. 2).

The Applicants agree with the Examiner on this point (i.e., that Tsukamoto fails to disclose or suggest the features of the "detecting" step) and also respectfully point out that Tsukamoto fails to disclose or suggest the features of the "analyzing" and "setting" steps recited in independent claim 2 (i.e., "analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output"; and "setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum.").

In Tsukamoto, the frequency analyzed is the frequency of the molten-pool (i.e., the periodic movement of the molten metal. However, nothing in Tsukamoto discloses or suggests analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency

component which is a same variation frequency of the laser output. Additionally, nothing in Tsukamoto describes setting a laser output variation condition, let alone setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum, as recited in independent claim 2.

Thus, Tsukamoto fails to disclose or suggest all the features of the “detecting,” “analyzing” and “setting” steps recited in independent claim 2. Additionally, neither Terada nor Chou overcomes all the deficiencies noted above in Tsukamoto.

In the Office Action, the Examiner relies on either Terada or Chou for disclosing or suggesting the “detecting” step, as recited in independent claim 2. However, the Applicants assert that neither Terada nor Chou disclose or suggest at least the features of the “analyzing” and “setting” steps recited in independent claim 2.

With regard to Terada, the Examiner relies on Figs. 4 and 6. In the description of Fig. 4, Terada discloses the relationship between a waveform of the pulsating laser beam and a waveform of the emission intensity at a weld zone. As described in Terada, the waveform related to emission intensity stays at a certain level while the welding beam input is present, and decreases abruptly a short time after the welding beam input drops (see col. 4, lines 33-43). Additionally, in the description of Fig. 6, Terada only discloses the two waveforms discussed above; one waveform of the pulsating laser beam and the waveform of the emission intensity at the weld zone.

Thus, Terada in the description of Figs. 4 and 6 merely discloses a correlation or relationship between the welding beam input and emission intensity at a weld zone. Terada fails to disclose or suggest “analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output” (“analyzing” step); and “setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum” (“setting” step), as recited in independent claim 2.

The Examiner alleges that Terada (in Figs. 4 and 6) discloses that it is well known that welding conditions are monitored and determined by the light intensity emitted from the welds. However, based on the above description of Terada, the reference only discloses a correlation or relationship between the welding beam input and emission intensity at the weld zone, which may include, for example, deducing the behavior of laser beam welding by monitoring the intensity of light of a predetermined wavelength immediately before a rise in the intensity of a pulsating laser

beam input. Terada fails to disclose or suggest the features of the "analyzing" and "setting" steps recited in independent claim 2.

Additionally, the welding quality considered by Terada considers penetration depth, which does not decrease welding defects such as porosity, blowhole and crack, which are welding issues addressed by the present invention (as recited in independent claim 2).

With regard to Chou, the Examiner does not point to a particular section of the reference but merely states that Chou discloses that it is well known that weld conditions are monitored and determined by the intensity of the light emission of a weld portion.

Chou more accurately discloses a method of monitoring laser weld quality. The method includes monitoring, at a position above a surface and as a function of time during the laser welding process, the spatial distribution of the intensity of light emitted from a plasma. Additionally, a numerical value is assigned to at least one physical dimension of the plasma to monitor the intensity of light, and the numerical value is compared to a predetermined value, wherein the predetermined value is representative of acceptable weld quality (see col. 2, lines 1-10).

Independent claim 2 recites "analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output," whereas Chou merely discloses monitoring the spatial distribution of the intensity of light emitted from a plasma, and assigning a numerical value to monitor intensity of light. Additionally, independent claim 2 recites "setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum." No such feature is disclosed or suggested by Chou.

Therefore, neither Terada nor Chou disclose or suggest all the features of the "analyzing" and "setting" steps recited in independent claim 2. Additionally, Kearney fails to overcome the deficiencies noted above in Tsukamoto, Terada and Chou. That is, Kearney also fails to disclose or suggest the "analyzing" and "setting" steps recited in independent claim 2.

In the Office Action, the Examiner again does not point to a particular section of the reference, but merely states that Kearney discloses that it is well known that the amplitude and wavelength of radiation emitted by a welding arc or plasma is detected by a sensor to determine weld conditions.

Kearney discloses a system for evaluating a weld by detecting the amplitude and wavelength of radiation emitted by a welding arc. Specifically, fiber optic pipes or bundles receive the radiant emission from a molten weld, and each fiber optic pipe or bundle transmits a different portion of the radiation spectrum so that the spectral components can be separated by the use of optical filters. The filtered spectral components are received by a phototransistor assembly that converts the filtered spectral components into electrical values. The electrical values are then amplified and provided as a signal that can be compared to a reference value, wherein the reference value is indicative of acceptable weld characteristics. Based on the comparison results, the welding operation can be interrupted and/or an alarm will sound (see col. 4, line 48-col. 5, line 42).

Independent claim 2 recites "analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output." Conversely, Kearney discloses filtering spectral components of the radiant emission of a molten weld, and comparing the filtered spectral components to a reference value. Nothing in Kearney discloses or suggests analyzing frequency characteristics of the light emission <u>to obtain an amplitude of a frequency component which is a same variation frequency of the laser output.</u> (Emphasis added).

Additionally, independent claim 2 recites "setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum," whereas Kearney merely discloses that welding operations are interrupted and/or an alarm is sounded if the filtering spectral components of the radiant emission of a molten weld exceed a reference value. Kearney makes no mention of setting a laser output variation condition, let alone <u>setting a laser output variation condition so that the amplitude of the frequency component becomes a maximum.</u> (Emphasis added).

Based on the above discussion, no combination of Tsukamoto, Terada, Chou, and Kearney would result in, or otherwise render obvious, all the features of independent claim 2. Additionally, no combination of Tsukamoto, Terada, Chou, and Kearney would result in, or otherwise render obvious, claims 5 and 6 at least by virtue of their dependencies from independent claim 2.

Moreover, at least dependent claim 6 is believed to be distinguishable from the cited prior art on its own merit. In the Office Action, it appears that the Examiner relies on Chou for

disclosing or suggesting the features of claim 6. In the Office Action, the Examiner states that Chou discloses that the strength of plasma can reach a threshold value that is indicative of a weld problem if it lasts more than 30ms, which is longer than 2ms.

However, the threshold disclosed in Chou is a digitized plasma intensity of 25 counts irrespective of intensity saturation. Thus, it is natural that the strength of the plasma reaches a threshold value (see e.g., column 5, lines 16-18). Additionally, Chou also discloses that the time duration of a dip during at least 30 ms is considered an important indicator of the localized weld problem (see e.g., lines 49 to 64, column 9) and a sudden decrease in the weld dimension, such as caused by a momentary decrease in the laser beam power that does not last for more than 30 ms, does not necessarily result in a bad weld (see e.g., lines 66, column 9 to line 2, column 10).

Accordingly, the Applicants have amended claim 6 to recite that the laser welding method includes "setting the laser output variation condition so that the sum of the time at which the light emission strength becomes the threshold value or less is set to <u>a range between 2ms to 12ms.</u>" (Emphasis added). The amendment to claim 6 is fully supported by the Applicants' disclosure (see e.g., Fig. 9, example "c"). Additionally, Chou clearly fails to disclose or suggest a range between 2 ms and 12 ms. Thus, claim 6 is also believed to be distinguished from the cited prior art on its own merit.

In the Office Action, claims 3 and 4 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Tasukamoto, in view of Terada or Chou. The Applicants also traverse this rejection for at least the reasons noted below.

With regard to independent claim 3, the claim recites *inter alia*, the following features:

"[a] laser welding method, comprising:…

<u>detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion</u>;

<u>setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume</u>; and

<u>setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum</u>. (Emphasis added).

The present invention (as recited in independent claim 3) is distinguishable from the cited prior art in that the welding method detects the time change in the light emission strength of a plasma or a plume generated from a laser welded portion, and then sets an arbitrary threshold

value to the time change in the light emission strength of the plasma or the plume. Additionally, a laser output variation condition is set so that the sum of time at which the light emission strength becomes the threshold value or less is a minimum.

As noted above, preventing weld defects greatly depends on “a waveform of the variation” and “a frequency of the variation” in the laser output, so it is important to optimize conditions of the variations in the laser output. In the present invention (as recited in independent claim 3), detection of the state in which an emission signal of the laser breaks off for a short time (i.e., causing a weld defect) can be made simple by setting an arbitrary threshold value to the time change in the light emission strength and detecting the time at which the light emission strength becomes the threshold value or less. Additionally, a laser output variation condition can be set so that the sum of the time at which the light emission strength becomes the threshold value or less is a minimum (see Applicants’ disclosure pg. 10, lines 1-12).

In the Office Action, the Examiner relies on the combination of Tsukamoto, and Terada or Chou for disclosing or suggesting all the features recited in independent claim 3. However, the Applicants assert that the combination of Tsukamoto, and Terada or Chou fails to disclose at least all the features of the “two setting” steps recited in independent claim 3.

Tsukamoto discloses a laser welding method for preventing welding defects by modulating a laser output in accordance with the frequency of the molten-pool (i.e., the periodic movement of the molten metal). That is, a pulse laser output is controlled to conform to the frequency of the reciprocating motion of molten metal (see e.g., ¶[0026]-¶[0027]).

In the Office Action, the Examiner acknowledges that Tsukamoto fails to disclose or suggest “detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion,” (i.e., “detecting” step) as recited in independent claim 3 (see Office Action, pg. 4).

The Applicants agree with the Examiner on this point (i.e., that Tsukamoto fails to disclose or suggest the features of the “detecting” step) and also respectfully point out that Tsukamoto fails to disclose or suggest the features of the two “setting” steps recited in independent claim 3 (i.e., “setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume”; and “setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum.”).

Independent claim 3 recites "setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume." Conversely, Tsukamoto only discloses controlling a pulse laser output to conform to the frequency of the reciprocating motion of molten metal. Additionally, nothing in Tsukamoto describes setting a laser output variation condition, let alone setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum, as recited in independent claim 3.

Thus, Tsukamoto, fails to disclose or suggest all the features of the "detecting" and "setting" steps recited in independent claim 3. Additionally, neither Terada nor Chou overcomes all the deficiencies noted above in Tsukamoto.

In the Office Action, the Examiner relies on either Terada or Chou for disclosing or suggesting the "detecting" and "setting" steps, as recited in independent claim 3. However, the Applicants assert that neither Terada nor Chou discloses or suggests at least the features of the "setting" steps (i.e., "setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume"; and "setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum.").

With regard to Terada, the Examiner again relies on the Figs. 4 and 6. However, Terada in the description of Figs. 4 and 6 merely discloses a correlation or relationship between the welding beam input and emission intensity at the weld zone. In Terada, there is no description of "setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume"; or "setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum," as recited in independent claim 3.

Additionally, the welding quality considered by Terada considers penetration depth, which does not decrease welding defects such as porosity, blowhole and crack, which are welding issues addressed by the present invention (as recited in independent claim 3).

With regard to Chou, the Examiner again does not point to a particular section of the reference but merely states that Chou discloses that it is well known that weld conditions are monitored and determined by the intensity of the light emission of a weld portion.

Chou discloses a method of monitoring laser weld quality. The method includes monitoring the spatial distribution of the intensity of light emitted from a plasma, assigning a

numerical value to at least one physical dimension of the plasma to monitor the intensity of light, and comparing the numerical value to a predetermined value, wherein the predetermined value is representative of acceptable weld quality (see col. 2, lines 1-10).

Although Chou discloses assigning a numerical value to at least one physical dimension of a plasma to monitor the intensity of light, the reference fails to disclose or suggest "setting an arbitrary threshold value <u>to the time change in the light emission strength</u> of the plasma or the plume." (Emphasis added). Additionally, independent claim 3 recites "setting a laser output variation condition so <u>that a sum of time at which the light emission strength becomes the threshold value or less is a minimum</u>" (emphasis added). Again, no such feature is disclosed or suggested by Chou.

Moreover, the welding quality considers in Chou relates to depth, which does not decrease welding defects such as porosity, blowhole and crack as addressed by the present invention (as recited in independent claim 3).

Based on the above discussion, no combination of Tsukamoto, Terada and Chou would result in, or otherwise render obvious, all the feature of independent claim 3. Additionally, no combination of Tsukamoto, Terada and Chou would result in, or otherwise render obvious, claim 4 and 8 at least by virtue of their dependency from independent claim 3.

Moreover, at least dependent claim 4 is believed to be distinguishable from the cited prior art on its own merit. In the Office Action, it appears that the Examiner relies on Chou for disclosing or suggesting the features of claim 4.

The Examiner states that Chou discloses that the strength of plasma can reach a threshold value that is indicative of a weld problem if it lasts more than 30ms, which is longer than 2ms.

However, the threshold disclosed in Chou is a digitized plasma intensity of 25 counts irrespective of intensity saturation. Thus, it is natural that the strength of the plasma reaches a threshold value (see e.g., column 5, lines 16-18). Additionally, Chou also discloses that the time duration of a dip during at least 30 ms is considered an important indicator of the localized weld problem (see e.g., lines 49 to 64, column 9) and a sudden decrease in the weld dimension, such as caused by a momentary decrease in the laser beam power that does not last for more than 30 ms, does not necessarily result in a bad weld (see e.g., lines 66, column 9 to line 2, column 10).

Accordingly, the Applicants have amended claim 4 to recite that the laser welding method includes "setting the laser output variation condition so that the sum of the time at which

the light emission strength becomes the threshold value or less is set to a range between 2ms to 12ms." (Emphasis added). The amendment to claim 4 is fully supported by the Applicants' disclosure. (see e.g., Fig. 9, example "c"). Chou clearly fails to disclose or suggest a range between 2 ms and 12 ms. Thus, claim 4 is believed to be distinguished from the cited prior art on its own merit.

The Applicants also assert that new independent claim 7 is also believed to be distinguishable from the cited prior art for similar reasons noted above for independent claims 2 and 3. That is, independent claim 7 also includes the novel features of independents 2 and 3 discussed above. Accordingly, no combination of Tsukamoto, Terada, Chou, and Kearney would result in, or otherwise render obvious, all the feature of independent claim 7.

The Applicants also submit herewith articles (i.e., as Attachment 1 and Attachment 2) that help support the Applicants' position that the claimed invention is not anticipated or rendered obvious by the prior art of record.

In light of the above, the Applicants submit that all the pending claims are patentable over the prior art of record. The Applicants respectfully request that the Examiner withdraw the rejections presented in the outstanding Office Action, and pass this application to issue. The Examiner is invited to contact the undersigned attorney by telephone to resolve any remaining issues.

Respectfully submitted,

Susumu TSUKAMOTO et al.

/Mark D. Pratt/
By 2010.06.23 13:07:14 -04'00'

Mark D. Pratt
Registration No. 45,794
Attorney for Applicants

MDP/clw
Washington, D.C. 20005-1503
Telephone (202) 721-8200
Facsimile (202) 721-8250
June 23, 2010